DEXTER RESEARCH CENTER, INC.

Thermopile Time Constant Determination

The time constant of thermopile detectors can be determined by several methods depending on the specific waveform of the radiation used to excite the detector. If the detector is subject to a step function of radiation, its response follows the function $V_t = V_{max}(1-e^{-t/\tau})$, where V_t is the detector output at any time t. The time constant (τ) of the system is defined as the time when V_t is 63.2% of its maximum static value $V_{max.}$

If the detector is subjected to sinusoidally modulated radiation, its frequency response follows the function $V_d = V_s[1+(2\pi\tau/T)^2]^{-1/2}$, where V_d is the dynamic amplitude of the detector output voltage at any wave period T, and V_s is the static amplitude of the output voltage generated by un-modulated radiation. The period T_o, at which the output amplitude V_d, falls off by 3dB (.707 V_s) from the static value, relates to the detector time constant by the expression $\tau = T_o/k\pi$, where k = 2 for sinusoidally modulated signals.

The waveform of chopper-modulated radiation corresponds closely to a square wave, and in this case the coefficient k = 1.124. The same relationship between the time constant and sine or square wave modulated radiation was found by Jones (see reference below).

A Red LED may be used with either method if the thermopile window/filter transmits in the visible spectrum. The appropriate coefficient should be applied depending upon the waveform used. At Dexter Research Center (DRC), the time constant is determined using two methods. 1) If the thermopile window/filter transmits in the visible spectrum then DRC uses a square wave modulated Red LED. 2) If the thermopile window/filter does not transmit in the visible spectrum, then DRC uses a chopped blackbody.

Direct measurement of the approximate time constant with a modulated signal is relatively simple and quick. Adjust the peak-to-peak trace of the detector's DC output to seven divisions on an oscilloscope using a very slow modulation frequency. Increase the frequency until the peak-to-peak trace spans five divisions (.707 x 7div. = 4.95div.). This is approximately –3 dB of $V_{max.}$ The time constant can then be determined from the frequency or from the wave period, again using the appropriate coefficient for the waveform utilized.

Infrared Detectors: Eds. Hudson & Hudson; Benchmark Papers in Optics, V.2; Dowden, Hutchinson, & Ross, Inc.; Stoudsburg, PA; J. Wiley & Sons, 1975. Page 324.